IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:Kimiaki TOSHIKIYO	Group Art Unit : 2622
Appl. No.	: 10/576,023 (U.S. National Stage of PCT/JP2004/018746	Examiner : D.A. Tejano
I.A. Filed	: December 15, 2004	Confirmation No. : 9379
For	: LIGHT-COLLECTING DEVICE AND SOLID-STATE IMAGING APPARATUS	

RESPONSE UNDER 37 C.F.R. §1.116

Commissioner for Patents
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Sir :

In response to the Final Office Action of November 20, 2009, in which a three-month shortened statutory period for response was set to expire on February 22, 2010 (February 20, 2010 falling on a Saturday), Applicant respectfully requests reconsideration and withdrawal of the outstanding rejections set forth in the above-mentioned Final Office Action in view of the following amendments and remarks.

Amendments to the Claims are reflected in a **Listing of the Claims** beginning on page 2.
Remarks begin on page 8.
A Terminal Disclaimer is attached hereto.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the current application.

LISTING OF THE CLAIMS

1. (Cancelled).

2. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein incident light is collected in a center of a plane made of said plurality of light-transmitting films, the incident light being incident at an angle asymmetrical to a center of a plane made of said plurality of light-transmitting films.

3. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein an amount of phase change of the incident light, $\phi(x)$, depends on a distance x in an in-plane direction and approximately satisfies the following equation,

$$\phi(x) = Ax^2 + Bx\sin\theta + 2m\pi$$

wherein θ is an incident angle of the incident light, A and B are predetermined constants, and m is a natural number.

4. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein

$$\Delta n(x) = \Delta n_{\max}\left[\phi(x)/2\pi + C\right]$$

is satisfied, where $\Delta n_{\max}$ is a difference of refractive indices between one of said plurality of light-transmitting films and a light-incoming side medium, $\Delta n(x)$ is a difference of refractive

indices between another one of said plurality of light-transmitting films and the light-incoming side medium at a position x, and C is a constant.

5. (Currently Amended) The solid-state imaging apparatus according to claim 9,

wherein heights of said plurality of light-transmitting films are constant in a direction normal to said plurality of light-transmitting films.

6. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein each of said plurality of light-transmitting films includes one of TiO_2, ZrO_2, Nb_2O_5, Ta_2O_5, Si_3N_4 and Si_2N_3.

7. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein each of said plurality of light-transmitting films includes one of SiO_2 doped with B or P, that is Boro-Phospho Silicated Glass, and Teraethoxy Silane.

8. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein each of said plurality of light-transmitting films includes one of benzocyclobutene, polymethymethacrylate, polyamide and polyimide.

9. (Currently Amended) A solid-state imaging apparatus comprising arranged unit pixels, each of which includes a light-collector and a light-receiver,

wherein said light-collector comprises:

a substrate into which incident light is incident; and

above said substrate, a plurality of light-transmitting films are formed in a region into which the incident light is incident,

wherein a light-transmitting film of said plurality of light-transmitting films forms ~~zones, in which a width of each zone~~ a zone having a width which is equal to or shorter than a wavelength of the incident light,

wherein each zone shares a center point which is located at a position displaced from a center of said light-receiver, and

said plurality of light-transmitting films form an effective refractive index distribution,

wherein, in a unit pixel, among said unit pixels, which is located at a center of a plane on which said unit pixels are formed, a position at which an effective refractive distribution of a corresponding light-collector is a maximum value matches a central axis of a corresponding light-receiver, and

wherein in a unit pixel, among said unit pixels, which is located at a periphery of the plane, a position at which the effective refractive distribution of a corresponding light-collector is a maximum value is displaced from the central axis of a corresponding light-receiver toward the center of the plane.

10. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein an off-centered light-transmitting film is formed in an area shared by one light-collector and another light-collector in an adjacent unit pixel.

11. (Previously Presented) The solid-state imaging apparatus according to claim 9, comprising:

a first unit pixel for a first color light out of the incident light; and

a second unit pixel for a second color light which has a typical wavelength that is different from a typical wavelength of the first color light;

wherein said first unit pixel includes a first light-collector , and

said second unit pixel includes a second light-collector, in which a focal length of the second color light is equal to a focal length of the first color light in said first light-collector .

12. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein a focal point is set at a predetermined position by controlling an effective refractive index distribution of said light-transmitting film.

13. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein each of said unit pixels further includes a light-collecting lens on a light-outgoing side of said light-collector .

14. (Previously Presented) The solid-state imaging apparatus according to claim 9,

wherein an effective refractive index distribution of said light-transmitting film is different between light-collectors of said unit pixels located at the center of said plane on which said unit pixels are formed and light-collectors of said unit pixels located at the periphery of the plane.

15. (Cancelled).

16. (New) The solid-state imaging apparatus according to claim 9,

wherein each of said plurality of light-transmitting films of one of said unit pixels located near the center of an imaging area has a line width different from a line width of each of said light-transmitting films of one of said unit pixels located at the periphery of the imaging area and is located at a same relative position in said light-collector as a position of each of said light-transmitting films of the one of said unit pixels located near the center of the imaging area, the imaging area being a plane area on which said unit pixels are formed, and

a sum of line widths of said plurality of light-transmitting films of the one of said unit pixels located near the center of the imaging area differs from a sum of line widths of said plurality of light-transmitting films of the one of said unit pixels located at the periphery of the imaging area.

17. (New) The solid-state imaging apparatus according to claim 16,

wherein each of said plurality of light-transmitting films of the one of said unit pixels located at the periphery of the imaging area has a line width shorter than a line width of each of said light-transmitting films of the one of said unit pixels located near the center of the imaging area and is located at a same relative position in said light-collector as a position of each of said light-transmitting films of the one of said unit pixels located at the periphery of the imaging area.

18. (New) The solid-state imaging apparatus according to claim 9,

wherein each of said plurality of light-transmitting films of one of said unit pixels located at the periphery of an imaging area has a line width shorter than a line width of each of said light-transmitting films of one of said unit pixels located near the center of the imaging area and is located at a same relative position in said light-collector as a position of each of said light-

transmitting films of the one of said unit pixels located at the periphery of the imaging area, the imaging area being a plane area on which said unit pixels are formed.

REMARKS

Initially, Applicant wishes to thank the Examiner for the detailed Final Office Action. In the outstanding Final Office Action, claims 9 and 11 stand provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 12 and 14 of co-pending U.S. Patent Application No. 10/576,273. Claims 2-5 and 9-14 stand rejected under 35 U.S.C. §102(b) as being anticipated by MEYERS (EP 0809124). Claims 6-8 stand rejected under 35 U.S.C. §103(a) as being unpatentable over MEYERS in view of DELLWO et al. (U.S. Patent No. 7,390,532).

Upon entry of the present amendment, independent claim 9 and dependent claim 5 will have been amended and new dependent claims 16-18 will have been added. The amendments to independent claim 9 and dependent claim 5 and the addition of new claims 16-18 should not be considered an indication of Applicant's acquiescence as to the propriety of any of the outstanding rejections. Rather, Applicant has amended independent claim 9 and dependent claim 5 and added new claims 16-18 to advance the prosecution and to obtain an early allowance of the claims in the present application.

Applicant respectfully traverses the provisional rejection of claims 1, 5-9, 11 and 15 on the ground of non-statutory obviousness-type double patenting. In this regard, Applicant is filing the attached terminal disclaimer merely to remove any issue as to whether the claims of the above-identified application and claims 12 and 14 of co-pending U.S. Patent Application No. 10/576,273 in any way conflict. However, neither Applicant nor the assignee intend to make any representation as to whether the invention to which any claim of the present application is directed would have been obvious in view of any issued patent, or whether an obviousness-type double patenting rejection would be appropriate if the enclosed terminal disclaimer were not

filed. The terminal disclaimer is being filed only to expedite the allowance of the pending claims. In view of the above, Applicant respectfully requests reconsideration and withdrawal provisional rejection of claims 1, 5-9, 11 and 15 on the ground of non-statutory obviousness-type double patenting.

Applicant respectfully traverses the rejection of claims 1-5 and 9-15 under 35 U.S.C. §102(b) as being anticipated by MEYERS and the rejection of claims 6-8 stand under 35 U.S.C. §103(a) as being unpatentable over MEYERS in view of DELLWO. According to one non-limiting embodiment of the presently claimed invention, an optimal effective refractive index distribution is achieved for each unit pixel, which allows each unit pixel located at the periphery of the claimed solid-state imaging apparatus to efficiently collect incident light and achieve the same sensitivity as is achieved at the center of the claimed solid-state imaging apparatus, even when light is incident obliquely and with a large angle of incidence with respect to a axis vertical to the surface of incidence. That is, the presently claimed invention implements a solid-state imaging apparatus that eliminates differences in light-collection efficiency due to an increase in an angle of incidence of incident light, and which has high sensitivity as well as high sensitivity uniformity.

In the *Response to Arguments* section of the Final Office Action, the Examiner asserts that the nature of diffractive lenslets is such that, at a central section of the lenslet array, the central points of the lenslets are in linear conjunction with the central points of the pixels and, toward the periphery of the lenslet array, the central points of lenslets are shifted so as to bend the oblique-angled incident light toward the center of the pixel. In particular, the Examiner points to FIGS. 2 and 3a of MEYERS.

In this regard, FIGS. 2 and 3a are submitted to illustrate bending light at a greater angle toward the edges of a viewing plane. MEYERS is submitted to disclose that the local displacement of the lens group's optical axis varies as a function of radial position relative to the center of the system's image optical axis (*see, e.g.*, page 4, lines 26-33 of MEYERS). Applicant respectfully submits that MEYERS is directed to a structure in which downwardly-convex lenses and apertures are positioned off-center with respect to pixels at the periphery of an image sensor having an array of light-receiving devices. It is submitted that the downwardly-convex lenses and apertures become increasingly off-centered in an outward direction from the center of the image sensor. Applicant respectfully submits that MEYERS discloses receiving incident light at the periphery of the image sensor by positioning a lenslets array 12 and apertures in an off-center manner, with respect to pixels located at the periphery of the image sensor and further, that the convex lenses and the apertures become increasingly off-centered in an outward direction from the center of the image sensor.

As best understood, the Examiner interprets the lenslet array 12 of the image sensor disclosed by MEYER as teaching a light-collector and asserts that the lenslet array 12 includes a plurality of light-transmitting films, and that each light-transmitting film (presumably, each lenslet in the lenslet array 12) forms a zone having an arbitrary line width equal to or shorter than a wavelength of incident light, and further that the lenslets in the lenslet array 12 form an effective refractive index distribution. Applicants respectfully submit that, assuming *arguendo,* that the Examiner's interpretation is correct, then the position at which the effective refractive index distribution of the lenslet array 12 is at a maximum value (*e.g.*, referred to as the central axis of the light-collector) is not defined per lenslet in the disclosed lenslet array 12. Rather, the position at which the effective refractive index distribution achieves a maximum value is

defined, in MEYERS, as the position at which the effective refractive index distribution of the entire lenslet array 12 is at a maximum value. Even if the central axis of the light-collector disclosed in MEYERS were definable, MEYERS is submitted to fail to disclose or suggest that in a unit pixel, among said unit pixels, which is located at a periphery of the plane, a position at which the effective refractive distribution of a corresponding light-collector is a maximum value is displaced from the central axis of a corresponding light-receiver, let alone that the displacement is toward the center of the plane, as recited in Applicant's independent claim 9.

The Examiner further asserts that the central axis of the light-collector being displaced from the central axis of the corresponding light-receiver toward the center of the incidence plane is equivalent to the central axis of the light-collector being shifted from the mechanical optical axis 14 of a corresponding lenslet 12. However, Applicant respectfully submits that in MEYERS, one lenslet 12 corresponds to three light receivers (*i.e.,* red, green and blue receivers), making it impossible to define the central axis of the corresponding light-receiver. Further, the claimed central axis of the corresponding light-receiver is different from the mechanical optical axis 14 of the corresponding lenslet 12, as disclosed in MEYERS.

Assuming, *arguendo*, that the lenslet array 12 disclosed in MEYERS were considered as being a single light-collector, each of the lenslets in the lenslet array 12 in MEYERS have a dufferent convex shape depending on a position of a pixel while maintaining the refractive indices of each of the lenslets in the lenslet array 12. While each lenslet 12 in FIG. 1 is drawn with topographical lines 15 indicating changes in height of the lenslet surface, the surface of each lenslet shown in the sectional view in FIG. 2 is shown as being smoothly curved. Accordingly, Applicant respectfully submits that the lenslet array 12 and each of the corresponding lenslets are not made of light-transmitting materials which form a plurality of zones. In contrast, the

claimed light-collector specified in Applicant's independent claim 9 is made of light-transmitting films which form zones each having an arbitrary line width equal to or shorter than a wavelength of incident light. This allows for symmetric and asymmetric effective refractive index distributions corresponding to shorter focal lengths, and the light is collected using differences in refractive indices. Accordingly, Applicant respectfully submits that MEYERS fails to disclose or suggest that a light-transmitting film of said plurality of light-transmitting films forms a zone having a width which is equal to or shorter than a wavelength of the incident light, as recited in Applicant's independent claim 9.

In addition, as shown in FIG. 1 of MEYERS, in order for the lenslet array 12 to include different fields of view, the length of the mechanical optical axis 14 of the lenslet array 12 between adjacent pixels is longer than the length of the mechanical optical axis 14 between the centers of the adjacent pixels. More particularly, the position of the mechanical optical axis 14 of the lenslet array 12 serving as a light-collector, in MEYERS, is submitted to be increasingly shifted outwardly from the pixel center as each lenslet is positioned farther away from the center of the lenslet array 12. Further, Applicant respectfully submits that, in any specified pixel, a lenslet is not displaced from the central axis of a photosensitive site 20, toward the center of the incidence plane. In contrast, in the presently claimed light-collector, the position at which the effective refractive index distribution is a maximum value, is shifted toward the center of the imaging area so that incident light collected by an optical lens is evenly received over the entire imaging area. Accordingly, even when incident light obliquely enters the periphery of the solid-state imaging apparatus, the incident light is efficiently collected in each unit pixel and the light-collecting sensitivity is the same as the light-collecting sensitivity at the center of the solid-state imaging apparatus.

As described above, the position at which the mechanical optical axis 14 of the lenslet array 12 disclosed in MEYERS is at a maximum, and the position at which the effective refractive index of the light-collector recited in independent claim 1 is at a maximum, differ in structure and effect. Accordingly, the teachings of MEYERS fail to teach or suggest "each and every" element of Applicant's independent claim 9, as would be required in order for a rejection under 35 U.S.C. §102 to be appropriate.

In view of the above, Applicant respectfully submits that MEYERS fails to disclose or suggest at least the above-noted features of Applicant's independent claim 9 and thus, Applicant's independent claim 9 is allowable over MEYERS.

Further, each of dependent claims 2-8 and 10-18 are submitted to be allowable at least because they depend from independent claim 9, which Applicant submits has been shown to be allowable. Each of dependent claims 2-8 and 10-18 are also submitted to recite further patentable subject matter.

With respect to the 35 U.S.C. §103 rejection of claims 6-8, it is submitted that DELLWO fails to cure the deficiencies of MEYERS noted above with respect to independent claim 9, from which claims 6-8 depend, nor is DELLWO applied to cure the above-noted deficiencies. As such, allowance of dependent claims 6-8 is submitted to be proper for at least the same reasons noted above for independent claim 9, upon which they depend, in addition to reasons related to their own recitations.

In view of the above, reconsideration and withdrawal of the rejection of claims 1-5 and 9-15 under 35 U.S.C. §102(b) as being anticipated by MEYERS and the rejection of claims 6-8 under 35 U.S.C. §103(a) as being unpatentable over MEYERS in view of DELLWO is respectfully requested.

Applicant notes that this Response is being submitted after a Final Office Action has been mailed. Applicant recognizes that Applicant cannot, as a matter of right, amend any finally rejected claims. However, Applicant also recognizes that any amendment that will place the application either in condition for allowance or in better form for appeal may be entered. Applicant respectfully requests entry and consideration of this Response, including the amendments provided herein, and believe such entry and consideration is proper. Applicant also respectfully requests the Examiner to reconsider and to withdraw all of the outstanding rejections made in the outstanding Final Office Action, and to allow the application to mature to a U.S. letters patent. Applicant believes that such action is now proper and called for, for at least the reasons provided below.

Should an extension of time be necessary, the Commissioner is hereby authorized to charge any additional fee to Deposit Account No. 19-0089.

Should the Examiner have any questions concerning this Response or the present application, the Examiner is respectfully requested to contact the undersigned at the telephone number listed below.

Respectfully Submitted,
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